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Introduction

When an extensive programme of grain rust research was undertaken in 1925 by the Dominion Department of Agriculture, added attention was given to the oat stem rust problem. This work was centered at the Dominion Rust Research Laboratory, Winnipeg. It was considered essential to obtain as much information as possible concerning the physiologic forms of oat stem rust in Canada before an adequate plant breeding programme could be undertaken.

Oat stem rust is more or less injurious in certain areas every year, but it was extremely serious in 1927, especially in Manitoba. In Western Canada, it usually appears first during the season in southern Manitoba about the first week of July. It soon attains epidemic proportions if conditions are suitable for its spread.

The work herein reported has been carried on since 1925 at the Dominion Rust Research Laboratory, Winnipeg. Previous to the above date, physiologic forms had been identified from only a very limited number of oat stem rust collections from Canada. Since then, greater facilities have been available for carrying on the work and more extensive rust surveys have been carried out each year. Members of the Dominion Laboratories of Plant Pathology have assisted greatly in the work by sending in numerous collections of rust.

Historical

The existence of physiologic specialization in *Puccinia graminis avenae* Erikss. and Henn., was first demonstrated by Stakman, Levine and Bailey (*1*) in 1923. In 1924, Bailey (*2*) reported definitely the occurrence of five physiologic forms. Forms 1, 2 and 5, were collected from widely separated points in the United States and Canada. Form 3 was obtained only in collections from Sweden and South Africa, and Form 4 was represented by a single collection from Sweden. Forms 1, 2 and 5, were isolated again by Bailey (*3*) in 1924, from a total of 26 collections made in Canada.

Methods

Collections of oat stem rust were made during the summer from the first appearance of the rust, until the end of the season. The majority of those obtained were on *Avena sativa* L. and *A. fatua* L. An occasional collection has been made on the barberry and on the grass hosts, *Dactylis glomerata* L. and *Torresia odorata* (L) Hitch.

All the work dealing with the identification of the physiologic forms was carried on in the greenhouse. The rust was first transferred to seedling plants of the Victory variety, which is susceptible to all the known physio-

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logic forms of *Puccinia graminis avenae*. Inoculum from this variety was then used to infect the differential hosts. The varieties or strains of oats which Bailey (*2*) found to be differential in their reaction, were used in this work. (Table 1). The physiologic forms were identified according to Bailey's Key (*2*).

TABLE 1.—*Reaction of differential hosts to physiologic forms of Puccinia graminis avenae*

Form	White Russian	Richland, Heigira Strain, Monarch Strain	Joanette Strain Strain 703	Victory
1	3c	2	1	4
2	3c	2	4	4
3	4	2	1	4
4	4	4	1	4
5	3c	2	×	4
6	4	4	4	4

ORIGIN OF COLLECTIONS

The majority of the oat stem rust collections identified each year were obtained from Manitoba and Saskatchewan (Table 2). Collections were obtained from Alberta and British Columbia only in 1927. A few collections have been available from Eastern Canada each year, chiefly from points where the Uniform Rust Nurseries were located (Figs. 5, 6, 7). A list of the localities in which rust was collected in 1925 is given in the Report of the Dominion Botanist for the year 1926. Similar data of the collections made in 1926 and 1927 will be published at a later date.

PHYSIOLOGICAL FORMS ISOLATED

In Table 2 is shown the number of collections made in each Province and the physiologic forms which were isolated from them. In Tables 4, 5 and 6, is shown the number of isolations of each physiologic form from the different Provinces in 1925, 1926, and 1927.

TABLE 2.

Province	1925		1926		1927	
	Number Collections	Forms Isolated	Number Collections	Forms Isolated	Number Collections	Forms Isolated
British Columbia	—	—	—	—	1	2,5
Alberta	—	—	—	—	45	1,2 5,
Saskatchewan	11	2,3,4,5,6	64	1,2,4,5	143	1,2 4,5
Manitoba	39	1,2,5	88	1,2,4,5,6	115	1,2,4,5,6
Ontario	3	2,	11	2,4,5	18	2,5
Quebec	3	2,5	9	2,5	9	1,2,5
New Brunswick	2	2,5	10	2,5	3	2,5
Nova Scotia	1	2,	5	5,	9	2,5
Prince Ed. Island	1	5,	5	5,	1	4,
Total Collections	60		192		344	
Physiologic Forms isolated in Canada		1,2,3,4,5,6		1,2,4,5,6		1,2,4,5,6

Physiologic Forms 2 and 5 have predominated each year. They comprise 95 per cent or more, of the total isolations, and both are widespread in Canada. The comparative frequency of occurrence of the physiologic forms is shown in Fig. 1.

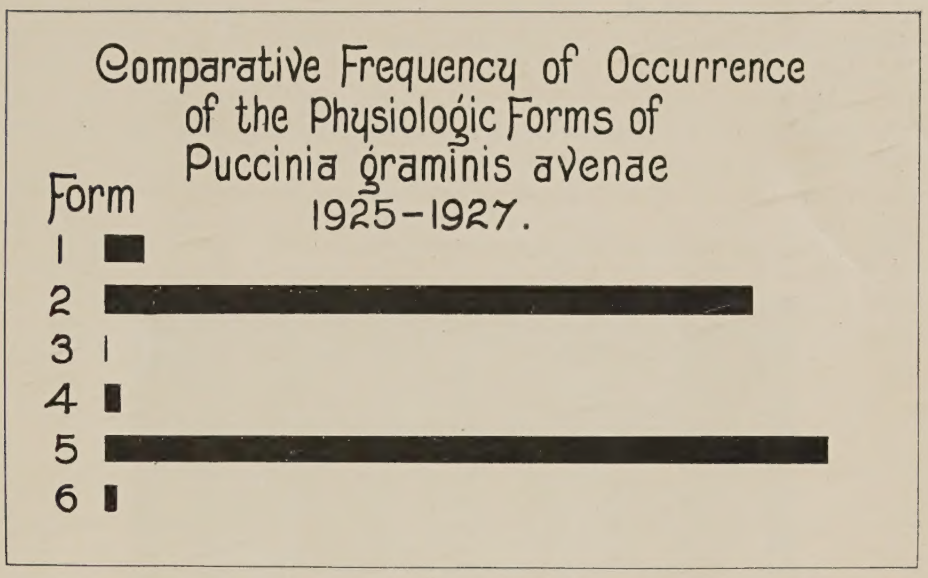

FIGURE 1

OCCURRENCE OF VIRULENT PHYSIOLOGIC FORMS OF *Puccinia graminis avenae.*

Previous to 1925, no physiologic forms were collected in Canada capable of infecting heavily the differential hosts, White Russian and the Richland group of differentials (Richland, Heigira Strain, and Monarch Strain). During 1925, however, collections of oat stem rust obtained from three more or less widely separated points in Saskatchewan, contained forms more virulent than the common Physiologic Forms 1, 2 and 5. Since then, virulent physiologic forms have appeared each year. Data concerning the collections and the forms isolated from them are presented in Table 3.

TABLE 3.—*Data concerning the collections of virulent physiologic forms of Puccinia graminis avenae in Canada.*

Rust Survey Number	Place of Collection	Date Collected	Physiologic Form	Host
		1925		
1	Paskwegin, Sask.	4–8	6	A. fatua
19	Indian Head, Sask.	14–8	4	A. sativa
40	Fairlight, Sask.	14–8	3 & 4	"
		1926		
63	Weyburn, Sask.	31–7	4	A. sativa
70	Pine River, Man.	5–8	4	A. fatua
78	McCreary, Man.	4–8	6	A. sativa
108	Winchester, Ont.	26–8	4	"
		1927		
6	Charlottetown, P.E.I.	7–7	4	Barberry
7	St. Jean, Man.	11–7	4 & 6	A. fatua
26	Wawanesa, Man.	17–7	4	"
130	Cartwright, Man.	7–8	4	A. sativa
136	Indian Head, Sask.	4–8	4	"

The most interesting and important physiologic form is the one collected for the first time at Paskwegin, Sask., in 1925. It was found to be capable of infecting heavily, all the differential hosts, which made it the most virulent form yet isolated. Its infection capabilities differ from all he other forms of *Puccinia graminis avenae,* so it is considered a new form and has been named Physiologic Form 6. Only three collections of this form have been obtained,—two from Manitoba and one from Saskatchewan. The typical reaction of all the differential hosts to this form is shown in Fig. 2. Form 4 has been collected ten times.

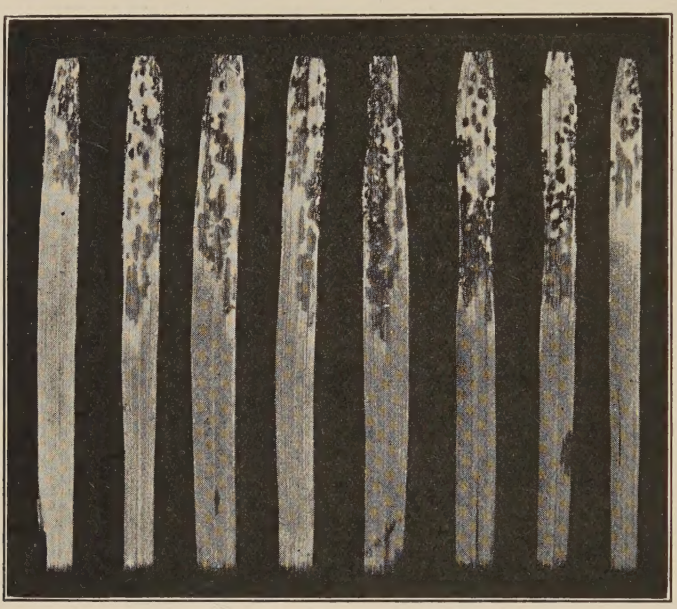

FIG. 2. The typical reaction of all the differential hosts to Physiologic Form 6.

This form was previously known to occur only in Sweden (*2*). Form 3 has been isolated once. These physiologic forms, although more virulent than Forms 1, 2, and 5, have been collected comparatively rarely.

THE HETEROGENEOUS OR X REACTION

Physiologic Form 5, one of the most frequently occurring forms, gives a heterogeneous or X reaction on two differential hosts, Joanette Strain and Strain 703 which react as a unit (Table 1). That is, on a single plant pustules may occur, varying from an extremely resistant type to an entirely susceptible type. Repeated attempts to make separations from any one type of pustule, result in the final production of the heterogeneous or X reaction again. Apparently the ordinary method of separation used when two or more physiologic forms are present on the same leaf is of little value in such cases.

Early in 1926, a study of this type of reaction was made by the single spore method. Spores from a culture giving an X reaction were thinly scattered on a sterile glass slide. The slide was then placed under the low

power of a compound microscope. Single spores were picked up by means of a sharp pointed needle, on the point of which was placed a very small amount of vaseline. The point of the needle was again examined under the microscope to be certain that only one spore was attached. The single spore was then placed on a leaf which had been previously moistened, after which the needle was sterilized before another spore was picked up.

About eight plants per pot were inoculated in this manner. These were enclosed by a glass cylinder on the top of which was placed a moist sheet of blotting paper. The pots were then placed in the ordinary moist chambers for 48 hours, when they were removed and placed on a bench in the greenhouse in a compartment made of cotton sheeting..

Only about two per cent of the plants inoculated with a single spore ever produced a pustule.

From a pustule produced from a single spore 62 plants, 27 of Joanette Strain and 35 of Strain 703, were inoculated. It was found possible to inoculate this many plants from a single pustule, by inoculating a few plants in intervals of about four days. It was interesting to find that the X reaction appeared on all of the 62 plants on the first transfer (Figs. 3 and 4 show the reaction of a number of the plants). Further single spore cultures of Form 5 produced additional evidence that the heterogeneous or X reaction could occur when inoculations were made with them. Additional work will be undertaken on the nature of this type of reaction when conditions in the greenhouse can be more adequately controlled.

Field Tests of Oat Varieties to Physiologic Forms

In the spring of 1926, more than 180 varieties or strains of oats in the Rust Nursery were sprayed with a spore suspension of all the physiologic forms. By the time the plants had headed, a very heavy infection had taken place. It was quite evident on the examination of the varieties or strains, ordinarily resistant in the Rust Nursery to Physiologic Forms 1, 2 and 5, that all were susceptible. Collections made from these varieties, and later identified in the greenhouse, showed that Physiologic Forms 4 and 6 were apparently responsible for their susceptibility.

Seedling Tests of Oat Varieties to Physiologic Forms 4 and 6.

Seedling tests of oat varieties for rust resistance were carried on in the greenhouse early in 1927, in the hope of obtaining a variety or strain resistant to Form 6. Some 230 varieties or strains of oats, obtained from various sources in Canada and the United States, were inoculated in the seedling stage. These varieties were tested also to Form 4 at the same time. All appeared to be quite susceptible to both physiologic forms.

As none of the varieties available in America showed any resistance, 100 additional ones were obtained through the courtesy of the Dominion Botanist, H. T. Güssow, from France, Germany, Sweden and Russia. It was discouraging to find that all were apparently susceptible to Form 6, and only one variety from France showed any resistance to Form 4.

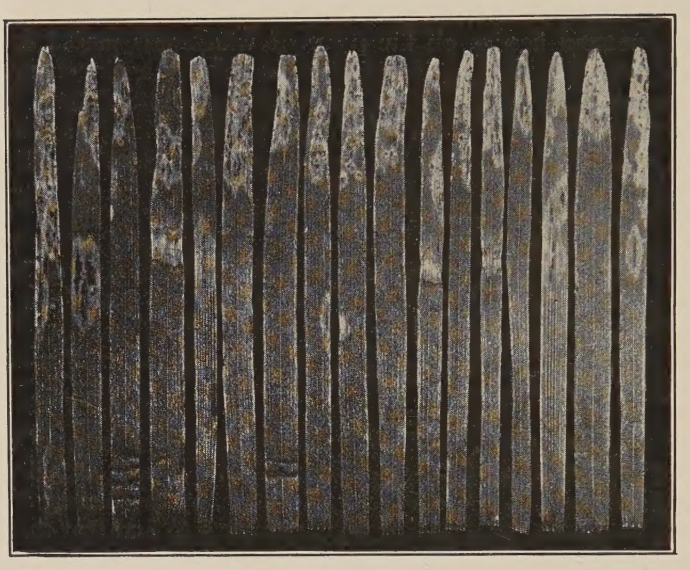

FIG. 3. The heterogeneous or X reaction of Joanette Strain produced as a result of inoculation with a single spore culture of Form 5.

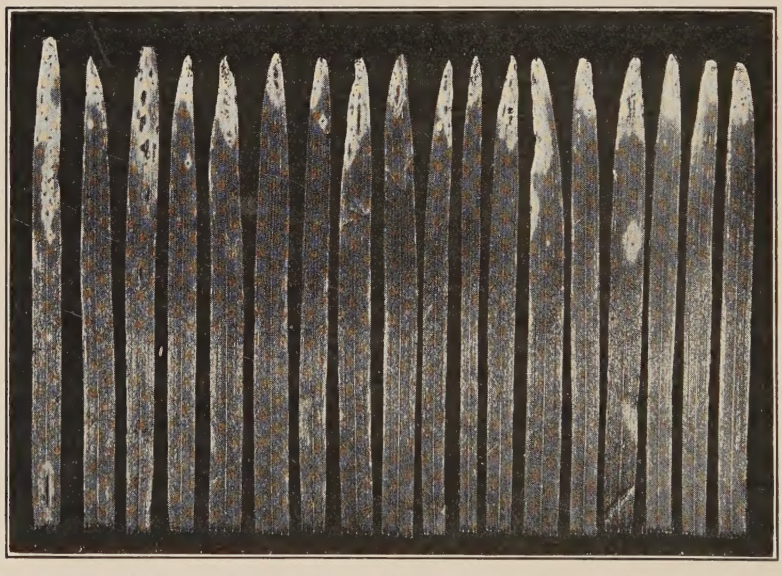

FIG. 4. The heterogeneous or X reaction of Strain 703 produced as a result of inoculation with a single spore culture of Form 5.

Form 6 appears to be exceedingly virulent. Nothing inoculated with it, to the present time, offers anything of value. The differential hosts, Joanette Strain and Strain 703, are the only strains of oats possessing a high degree of resistance to Form 4.

Summary.

1. Six physiologic forms have been isolated in Canada during the period 1925-1927.
2. Physiologic Forms 2 and 5 have predominated each year.
3. Forms 3 and 4 are reported for the first time as occurring in Canada.
4. Form 6 is reported as a new physiologic form.
5. The heterogeneous or X reaction, given by Form 5 on Joanette Strain and Strain 703, is shown to occur from single spore cultures.
6. Tests of numerous oat varieties have shown the extreme virulence of Forms 4 and 6.

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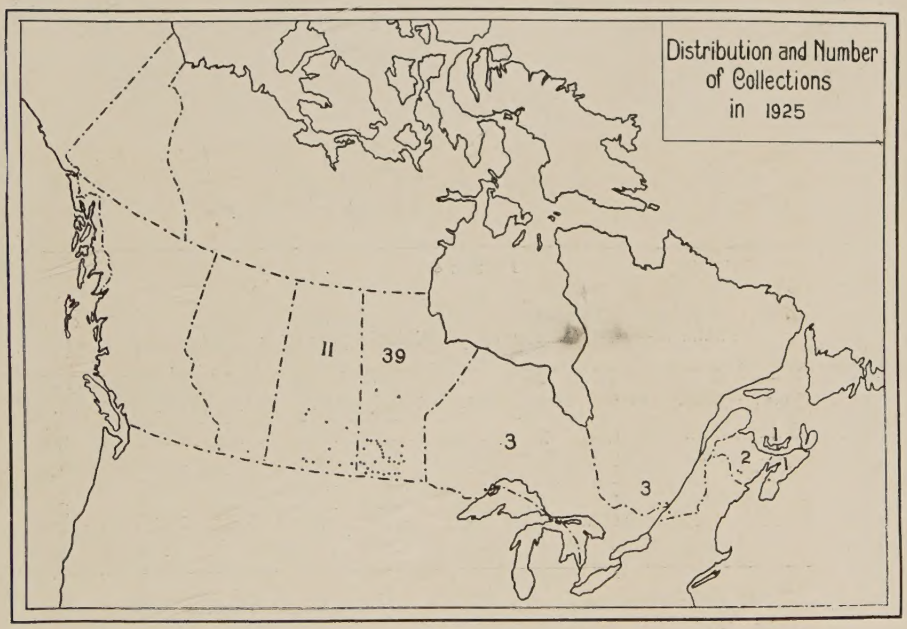

Figure 5

Table 4.—*Distribution of physiologic forms in 1925.*

Form	B.C.	Alta.	Sask.	Man.	Ont.	P.Q.	N.B.	N.S.	P.E.I.	Total Isolations
1	—	—	—	2	—	—	—	—	—	2
2	—	—	7	19	3	2	1	1	—	33
3	—	—	1	—	—	—	—	—	—	1
4	—	—	2	—	—	—	—	—	—	2
5	—	—	2	26	—	1	1	—	1	31
6	—	—	1	—	—	—	—	—	—	1

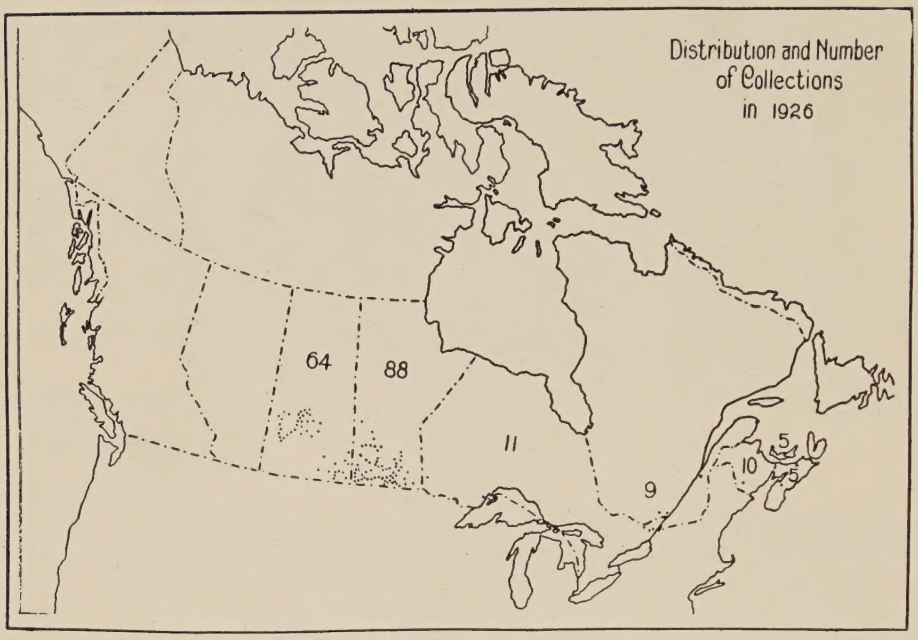

FIGURE 6

TABLE 5.—*Distribution of physiologic forms in 1926.*

Form	B.C.	Alta.	Sask.	Man.	Ont.	P.Q.	N.B.	N.S.	P.E.I.	Total Isolations
1	—	—	1	2	—	—	—	—	—	3
2	—	—	31	35	5	4	4	—	—	79
3	—	—	—	—	—	—	—	—	—	—
4	—	—	1	1	1	—	—	—	—	3
5	—	—	45	66	8	6	9	5	5	144
6	—	—	—	1	—	—	—	—	—	1

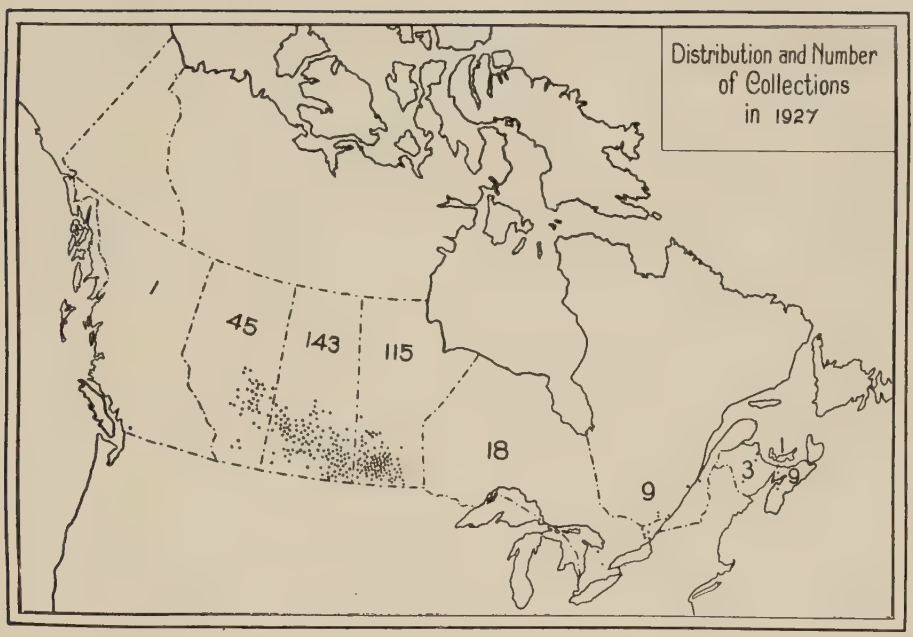

FIGURE 7

TABLE 6.—*Distribution of physiologic forms in 1927.*

Form	B.C.	Alta.	Sask.	Man.	Ont.	P.Q.	N.B.	N.S.	P.E.I.	Total Isolations
1	—	2	3	4	—	1	—	—	—	10
2	1	16	59	56	12	2	1	4	—	151
3	—	—	—	—	—	—	—	—	—	—
4	—	—	1	3	—	—	—	—	1	5
5	1	35	95	68	7	7	3	5	—	221
6	—	—	—	1	—	—	—	—	—	1